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AN INTELLIGENT SIMULATION TRAINING SYSTEM

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ABSTRACT

The Department of Industrial Engineering at the University of Central Florida, Embry-Riddle Aeronautical University and General Electric (SCSD) have been funded by the State of Florida to build an Intelligent Simulation Training System.

One objective was and is to make the system generic except for the domain expertise. We have accomplished this objective in our prototype. The system is modularized and therefore it is easy to make any corrections, expansions or adaptations.

The funding by the state of Florida has exceeded $3 million over the past three years and through the 1990 fiscal year. UCF has expended in excess of 15 work years on the project. The project effort has been broken into three major tasks. General Electric provides the simulation. Embry-Riddle Aeronautical University provides the domain expertise. (Our first prototype demonstration is in Air Traffic Control (ATC) training). The University of Central Florida has constructed the generic part of the system which is comprised of several modules that perform the tutoring, evaluation, communication, status, etc.

This paper describes the generic parts of the Intelligent Simulation Training Systems (ISTS).

INTRODUCTION

The Intelligent Simulation Training System project is a joint effort between the University of Central Florida (UCF), Embry-Riddle Aeronautical University (ERAU) and the General Electric (GE) Company. The objective was to develop a simulation-based training system that could conduct content training without the human instructor being continuously involved.

The instructor will plan the general outline and content of a course. The system will 'intelligently' interact with the trainee during the lessons. The student will be able to communicate with the instructor and vice versa through the system. This system is extending computer-based instruction (CBI) by introducing improved interactions between the computer system and the trainee.

UCF acts as the project manager. The UCF portion of the project involves building the parts of the system (computer program code) that actually conduct the training. Care has been taken to insure that the completed system is generic so that it will be useful in many subject areas.

Embry-Riddle Aeronautical University is programming the rules by which an Air Traffic Controller actually controls air traffic. The choice of air traffic control training as a first subject area is a good choice since it will allow us to fully test our final product. ERAU has the expertise to build that set of rules.

General Electric provides the simulation through their Simulation and Control Systems Department at Daytona Beach. Simulation is an area where GE has expertise, capability, experience, and equipment.

A natural breakdown of the project is three parts:
1) simulation; 2) the rules used in the subject area; and, 3) the teaching component. The system uses the emerging technologies of computer systems

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(hardware and software) and artificial intelligence (in particular expert systems technology). We have programmed the prototype on Symbolics' Machines using LISP and Flavors. We are planning to port the system to a version of the C language on a 386-based machine.

BUILDING A GENERIC INTELLIGENT SIMULATION TRAINING SYSTEM

We had many lengthy discussions on how we could build a generic ISTS. The key comes from a realization that the domains in which simulation is a viable training methodology are those in which you want the trainee to learn how to control/manipulate/understand objects in time and space. When using a simulation, the student pilot learns to control an object in time and space. The gunner/rocketeer learns how to understand or interpret what is happening in time and space to respond to it. The radar operator learns how to interpret and predict what will happen in the time-space domain. The Air Traffic Controller learns how to control objects in time and space.

In general, all simulations involve time and space and constraints on time and space. Therefore, with care, one can build a generic intelligent simulation training system in which the domain-independent and the domain-dependent knowledge are separate. We read the domain-dependent knowledge into the system at initialization.

THE SYSTEM COMPONENTS

The ISTS is programmed in modules for easier development, maintenance and for transportability. In our research of the literature relative to CBT (Computer-Based Training) and ITS (Intelligent Training Systems) we found that there were some major concerns that had not been addressed. Most of these concerns arose because of our goal of building a generic system. We found that no one had separated the evaluation system from the student model. Also, we found no systems where the domain expert and the domain instructor were treated as separate entities. We've all known domain experts who were/are poor instructors. (Also, some very good instructors would not be considered to be domain experts.) Based on our findings, we have constructed modules which we placed into six groups.

. Interface Group
  .. Author Module - a user-friendly interface for input of domain expertise.

  .. Discourse module - menu-driven communication module between the system and the user. (Input is currently through a keyboard but will be by voice at a future time.)

. Input Group
  .. Translator - accepts or rejects input on the basis of understanding: correct spelling, ability to parse and correct syntax.
  .. Input Filter - Accepts or rejects input based on the constraints of the operational domain.
  .. Intelligent preprocessor - updates current events list for the simulation.

. Control Group
  .. Interpreter - compares updated event list with pre-input event list and checks for critical events.
  .. Control - activates proper module(s).
  .. Inference Engine - makes inferences from rules.

. Instruction Group
  .. Evaluator - determines the merit of student input.
  .. Student model - maintains current status of student.
  .. Tutor - makes instructional decisions based on information from Student Model and Evaluator.

. Domain Expertise Group
  .. Domain Expert - facts, rules and heuristics for operating in the domain.
  .. Domain Expert Instructor - facts, rules and heuristics on how one instructs and evaluates in the domain.

. Simulation - appropriate simulation for instructing in the domain.

The systems modular structure is shown in Figure 1 and the data flow is shown in Figure 2. The types of data flow in Figure 2 are presented in Table 1. The Control Module oversees all of the necessary communication.

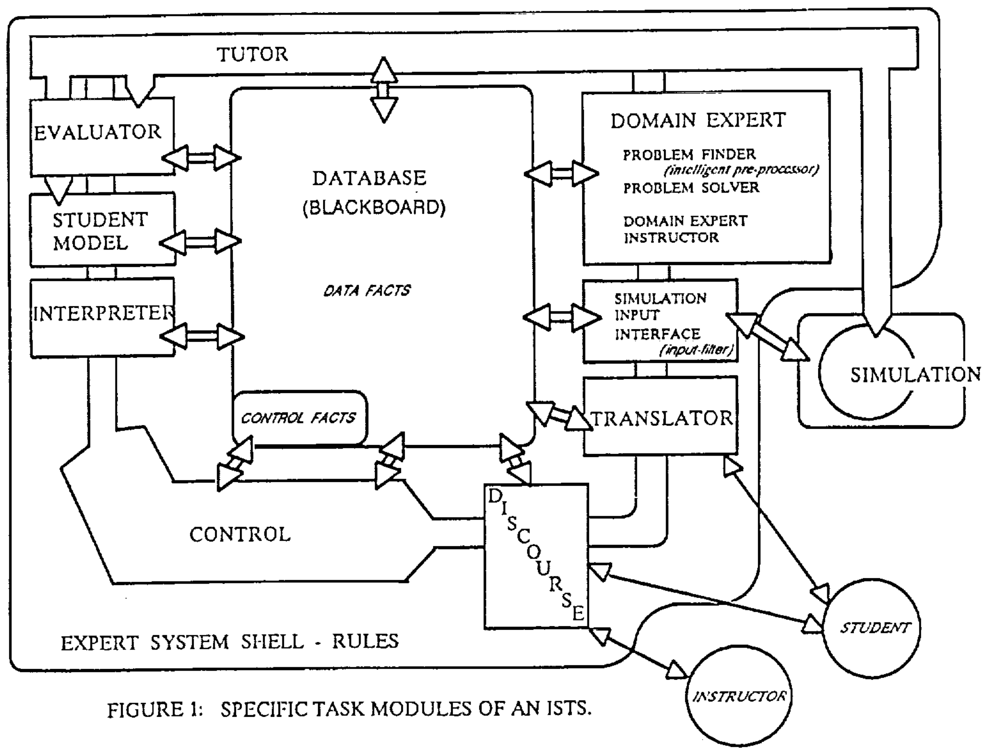

FIGURE 1: SPECIFIC TASK MODULES OF AN ISTS.

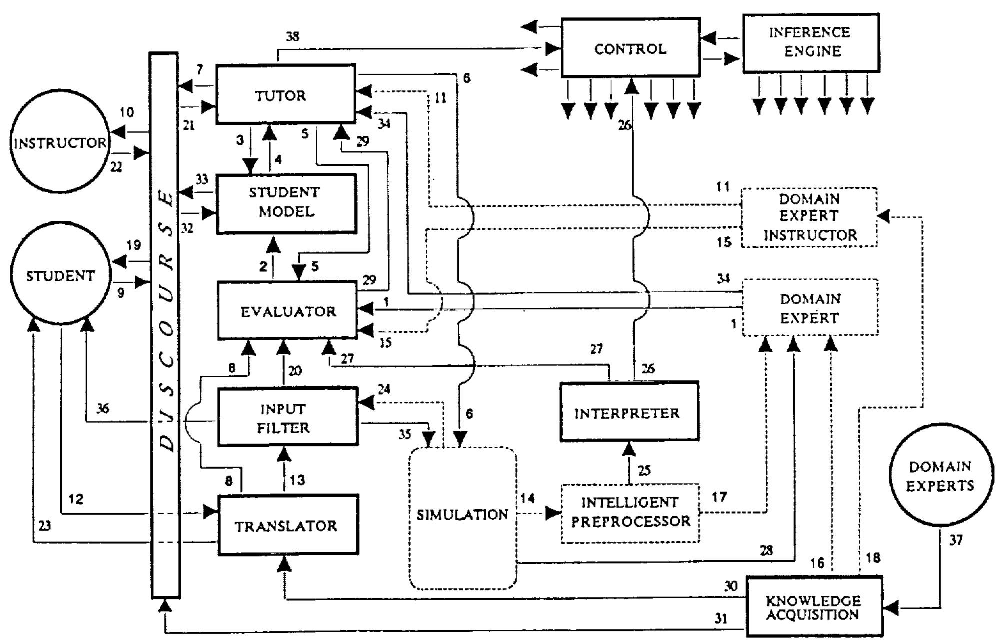

FIGURE 2: ISTS DATA FLOW DIAGRAM

Legend: ———— ISTS modules and data flow; - - - - - Interfacing Modules and data-flow

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Table I. Communications Within the ISTS

Key	Information Transferred
1.	Expert response to scenario.
2.	Raw score data.
3.	Refined score/status (performance rating).
4.	Remediation level and topics (to be stored).
5.	Skills/objectives to be taught.
6.	Scenario modification information.
7.	Topic, level of remediation, and final score.
8.	Parsed student commands and syntax errors (if any).
9.	All student input other than commands to simulation.
10.	Instructor inputs and requests.
11.	Domain teaching methods, lesson plans, scenarios, etc.
12.	Student response to scenario (commands).
13.	Parsed and syntactically correct student input.
14.	Plane data (vector, altitude, heading, speed), weather, emergencies, pilot requests, etc.
15.	Lesson plan, weighting factors.
16.	Domain Expert knowledge base.
17.	List of significant events (or possible events) extracted from the simulation.
18.	Domain instruction knowledge base.
19.	System's communication to student.
20.	Result's of logical analysis of student's parsed input.
21.	Student/instructor request.
22.	Communication from system to instructor.
23.	Error messages (syntax errors and uninterpretable input).
24.	Inputs refused by simulation objects.
25.	List of significant events (or possible events) extracted from the Simulation.
26.	Changes in events list.
27.	Changes in events list.
28.	Data read from simulation objects in order to generate expert solutions to events.
29.	Logical errors and specific information on student performance within the domain.
30.	Keyword and attributes for the domain.
31.	"Canned" messages for communication purposes.
32.	Student/Instructor comments.
33.	Access to student records.
34.	Why & how explanations to Domain Expert solutions.
35.	Executable message to a simulation object.
36.	Error messages sent to student (inputs refused by Input Filter).
37.	Off-line input from the system analyst.
38.	Tutor requests to activate other modules individually.

KNOWLEDGE REQUIREMENTS

An Intelligent Simulation Training System (ISTS) must contain four kinds of knowledge: (The following discussion is in reference to Figure 1.)

An ISTS must contain knowledge about the trainee. This knowledge is comprised of past performance, present performance, personal limitations and the trainee's preference as to teaching mode and type of feedback. This knowledge resides in the STUDENT MODEL.

The TUTOR contains general knowledge about teaching with simulations. The tutorial decisions about helping the student or modifying the simulation are based on dynamic information read from the EVALUATOR and the STUDENT MODEL.

The third type of knowledge is about the simulation domain. The ISTS must perceive the presence of simulation events that are of importance to a training program. This knowledge resides in the PROBLEM FINDER within the DOMAIN EXPERT Group. Since there may not be a simple solution to a particular simulation scenario, the PROBLEM SOLVER within the DOMAIN EXPERT will provide alternate solutions with a measure of merit for each. The EVALUATOR has the knowledge to evaluate the trainee's solutions by comparing them with the DOMAIN EXPERT's solutions. The ISTS must know how to monitor the syntactic and logical constraints that govern the instructions that the trainee gives to the SIMULATOR.

New knowledge about the student is gained during training sessions. The system continuously monitors for past performance (STUDENT MODEL), determines what the student has just asked the system to do (TRANSLATOR) and evaluates that action (EVALUATOR).

To use the above knowledge in a training session, it is necessary to have an interface (DISCOURSE) that allows the instructor to set up lessons, sequence lessons, determine content, degree of difficulty, enter pass/fail criteria, etc. This module must be sufficiently versatile for the student to get help, communicate with the simulation and to comment about 'things' for the edification of the instructor.

The SIMULATOR supporting such a system must have forward data links for the passage of student actions, tutorial modifications and monitoring the actions of the simulation. It must also have feedback links for the analysis of current data and a run-time reaction speed near real-time.

Another major area is in knowledge acquisition and knowledge representation. We are working on an interface to do this in a generic way.

AIR TRAFFIC CONTROL TRAINING

Our demonstration and first prototype is being done in the Air Traffic Control (ATC) domain. This is a situation in which the trainee can and does control the moving objects in time and space. Typically, in simulation training, the student controls only one object (pilot training) or no objects (radar target detection). The control of the simulation in ATC passes from student to SIMULATOR to student, etc. That is, the student drives the simulation which then drives the student until a new decision to take action is made. After the student directs the simulation action and the simulation responds, the simulation is again driving the student.

The objective of simulation training is to train the student to visual the real-world in time and space and to understand how his/her actions alter that time-space domain.

RESULTS

We have shown that a generic intelligent simulation training system is feasible. We have also developed some concepts for such a system; namely:

- Evaluation is a process separate from the tutoring process and the student modeling process.
- There must be a domain expert knowledge base and a domain instructor knowledge base.

CONCLUSIONS

We have developed and demonstrated that it is possible to build an Intelligent Simulation Training System. Our first application has been in ATC. Any area in which simulation is a viable training/teaching method can be taught with an ISTS. To move into a new domain only requires the development of the domain-dependent knowledge which can be 'read' into the generic system.

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